7-8

Biodiesel and India's Rural Economy

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Executive Summary

With annual economic growth rates of more than 7 percent and a population of well over a billion, India has a huge amount of global clout, both economically and environmentally. Although this recent economic growth has lifted millions out of dire poverty, millions more remain marginalized from the booming economy, and India will require massive amounts of resources to achieve its goal of reaching the status of a "developed" nation. Moreover, this growth must be achieved sustainably to prevent the short-term impacts from being overshadowed by long-term environmental degradation.

Alternative energy sources will play a role in maintaining economic growth while also addressing the growing concerns about sustainability. Biodiesel, a plant-based substitute for fossil diesel, reduces the carbon dioxide, carbon monoxide, and particulates emitted from internal combustion engines. It is a technology that can reduce dependence on oil imports and the negative environmental impacts of burning fossil fuels, while at the same time offering potential growth in the rural economy. The government of India argues that biodiesel production, especially from the planting of *Jatropha curcas* on degraded or marginal lands, could play a significant role in addressing these economic and environmental concerns while also creating a vibrant new rural industry. A major initiative is currently underway to simultaneously develop the production capacity of inedible oilseeds from *Jatropha curcas* and the infrastructure required to process the seed oil into biodiesel for use as transportation fuel. Thousands of jobs could be created, and millions of dollars could go to the struggling rural economy. There is little reason to question the continued growth of the oil market, and capturing a share of that market could offer enormous economic benefits to the rural sector.

This case presents some of the difficulties and potential pitfalls of achieving those goals. These difficulties include technological and structural issues of production, such as developing the appropriate equipment and infrastructure for oilseed production and expelling, converting the oil to biodiesel, and developing end-user equipment. Ecological issues concern the lack of scientific information on the chosen species, including long-term research on agronomic issues relating to pests and disease, production techniques, and breeding of productive genotypes. Finally, social issues concern the development and implementation of appropriate policies and incentives that protect vulnerable populations from potential harm, in the form of lost labor opportunities, unfamiliar new markets for seed crop sales, and the potential for changing food prices due to displacement of less profitable food crop production. In conclusion, oilseed development policy must take into consideration the production limitations of individual small farmers, while still encouraging the sector to grow large enough to allow for economic production of biodiesel and to make a real environmental impact.

Your assignment is to recommend to the government a policy to guide the development of biodiesel that takes into account the interests of the various stakeholder groups.

Background

The Booming Indian Economy

The perception of the role that India will play in the future global economy has changed dramatically in the past 15 years. Since India liberalized its economy in 1991, the real growth rates of gross domestic product (GDP) have remained consistently greater than 5 percent (7.6 percent in 2005) and created a society that is moving in the direction of high mass consumption. Given that the population is well over a billion people (one-sixth of the world's population) and still growing at 1.93 percent annually, the potential amount of resources that will be needed to feed the continued growth will be enormous. Despite these impressive economic growth rates, more than 25 percent of the population lives below the poverty line, with rural poverty rates at 30 percent or more. More than 20 percent of the national population is still undernourished (Government of India 2002). A continued effort must be made to include these segments of the population in future economic planning so that they can also access the opportunities of growth and not fall further behind.

One influential variable in the future growth of this booming economy is the energy sector. Meeting the demand for energy for residential and commercial needs will prove challenging. The focus of this case study is transportation fuel, and specifically the production of biodiesel from an oilseed-bearing shrub called *Jatropha curcas*. With the demand for transportation fuel growing at 6.8 percent a year, it is projected that by 2020, India will become the third-largest consumer of transportation fuel in the world, after the United States and China. The number of vehicles on the road jumped from 20 million in 1991 to 50 million in 2000 (Government of India 2002). Not only has the growing middle class begun to demand personal vehicles, but the growing urban population has an increasing need for transportation as well. The number of two-wheelers and autorickshaws (most of which run on highly polluting two-stroke engines) in cities of more than 100,000 people is expected to climb from a rate of 102 to 393 per 1,000 inhabitants in the next 20 years (Francis et al. 2005). Also, the demand for transportation of goods and raw materials by commercial carriers will continue to grow with the economy. Although biodiesel production can address only a small portion of this demand, it is certain that the aggregate demand for transportation fuel will only continue to increase.

Concerns for the Future

Beyond the question of quantity and availability of energy sources are several other concerns. The first concern is insufficient domestic fossil fuel resources. In 2003–2004 India imported 70 percent of its crude oil at a cost of US$18.36 billion, and it can only expect these numbers to grow. The greatest increase in demand is in the transportation sector, which meets 95 percent or more of its needs from fossil fuels (Kumar and Mohan 2005). Diesel fuel accounts for 40 million tons annually, constituting 40 percent of the overall fossil fuel market. Diesel's share in the market is growing at 5.6 percent per year and was expected to reach 52.32 million metric tons by 2007 (Dhawan 2004). All countries are beginning to recognize the threat of the unstable world crude oil market and are positioning themselves to gain access to the remaining global oil reserves. Indian policy makers must deal with the fact that most of their oil comes from the highly volatile Middle East and is therefore subject to the price fluctuations inherent in that region's instability.

A second concern is the environmental impact of the combustion of fossil fuels. Although per capita emission of air pollution in India remains low, the sheer volume of people requiring energy resources has exacerbated the problem to the point where India has become the world's fifth-greatest emitter of carbon dioxide (Government of India 2003). Urban areas are most affected by air pollution because of the high density of internal combustion engines. New Delhi has the fourth-worst air quality in the world, and 70 percent of that pollution comes from the transportation sector, leading to the results of one dramatic study that attributed an average of one death per day to air pollution in that city (Government of India 2002). Since 1998 major legislative efforts have been undertaken to combat these issues, including banning all diesel carriers within city limits, a forced transition to compressed natural gas (CNG), and a requirement to update all publicly or privately owned vehicles in the public transportation fleet, such as the autorickshaws. These measures have improved air quality considerably, but as the absolute number of vehicles continues to rise, pollution is sure to follow, regardless of efficiency measures.

A third concern for the energy sector regards the inevitable eventual shift away from fossil fuels. Although present needs for transportation must be met, every investment in current technology is one that will continue to contribute to the existing problems. The present fleet of vehicles will grow increasingly inefficient with age, and the sources of air pollution will only multiply as the demand for vehicles grows. Interim solutions, such as biofuels, as well as long-term solutions from new technology, must be explored.

The Role of Biofuels

To combat these global problems, many governments are promoting the development of biofuel technology. Biofuels are simply any fuel derived from recently living matter. Wood could even be considered a biofuel, but this case will focus on the two forms of biofuels that are being developed specifically for use as transportation fuels: ethanol[1] and biodiesel.

[1] This case is not directly concerned with the use of ethanol for fuel, but this information is needed for background context. The rest of the case will focus on biodiesel specifically from the production of *Jatropha curcas*.

Ethanol is alcohol distilled from plant carbohydrates, such as sugarcane, sorghum, or corn, that can be used as a fuel or fuel additive. With minor engine modifications ethanol can be used as fuel at 100 percent concentration, or with no engine modification it can be blended with petroleum gasoline in various percentages. Ethanol offers many benefits, such as reducing emissions and dependence on imported oil, while also developing the agricultural economy. Substantial growth in ethanol use has taken place worldwide. Thanks to massive amounts of available arable land and water, as well as long-term programs promoting the development of a supporting infrastructure and industry, Brazil has emerged as the global leader (Goldemberg et al. 2004). India has similar programs that guarantee certain levels of production and legislate a certain mixture of ethanol and petroleum gas at the pump. By 2003 a blend of 5 percent ethanol had become mandatory in nine states, and it was to be expanded to the rest of the country and increased to a higher percentage mix within a few years (Francis et al. 2005). Although there is certainly a future for ethanol production in India, especially considering the use of alternative feedstocks (such as sweet sorghum or other grasses) or improved technologies (such as cellulosic ethanol), the programs thus far have been criticized for questionable overall rates of energy production and the use of agriculturally productive land, water, and other resources for fuel production in a country with large numbers of food-insecure people.

The other biofuel, biodiesel, consists of fatty acid ethyl or methyl esters derived from plant oil, which can serve as a replacement for or additive to fossil diesel and can be used in compression ignition diesel engines with little or no modification. Virgin or used plant-based oil is converted to biodiesel through a simple chemical process called transesterification, in which alcohol replaces the glycerin from the oil molecules. A catalyst, in the form of an acid or a base (bases such as potassium or sodium hydroxide, called "lye," are commonly used), and alcohol (ethanol or methanol) are added to the oil at approximately 15 percent by volume, resulting in a separation of the oil into biodiesel and glycerin. As it did for ethanol, the Indian government planned to legislate mandatory mixes of biodiesel and petroleum diesel beginning in 2005 (Government of India 2003) with the intention of increasing the number of regions under this legislation and the percentage amount of biodiesel over time in order to promote the development of both public and private enterprises in various aspects of biodiesel production.

Given that production of biodiesel will never be able to entirely displace fossil diesel, the use of biodiesel as an interim technology, which takes advantage of and improves upon the existing infrastructure, is certainly worthy of the government's interest. The benefits of biodiesel can be divided into two categories: (1) environmental and (2) economic.

Environmental benefits of biodiesel. Fossil diesel has many negative characteristics that can be remedied by the inclusion of biodiesel in the mixture. B20 (a 20 percent biodiesel/80 percent fossil diesel mix) is accepted as a reasonable clean fuel alternative by the U.S. Department of Energy and has been shown to reduce emissions of unburned hydrocarbons, carbon monoxide, and other airborne toxins owing to its higher percentage of dissolved oxygen, which causes a more complete combustion (U. S. Department Energy 2006). A major problem with diesel technology is particulate emissions, which are reduced by 25–50 percent in B20 blends. Sulfur must also be added to fossil diesel to lubricate injectors but is unnecessary in biodiesel, and therefore sulfur emissions are reduced or eliminated. All of this is accomplished without a substantial loss of engine power or efficiency (Government of India 2003). A U.S. Environmental Protection Agency report found that biodiesel production eliminated lifecycle CO_2 emissions and called it "carbon-neutral," meaning that unlike fossil fuels, the net carbon accumulated in the growth of the plant and then released again via combustion results in a net gain or is neutral (Francis et al. 2005). Use of biodiesel thus leads to a reduction or stabilization of greenhouse gas emissions and could play a role in international environmental treaties such as the Kyoto Protocol.[2] Production of biodiesel also has possible beneficial environmental impacts, such as wasteland reclamation, reforestation, soil erosion control, and improvement of soil organic matter, depending on which plant sources are chosen and how the oil-bearing plants are grown.

2 The Kyoto Protocol is an amendment to the international treaty on climate change, assigning mandatory targets for the reduction of greenhouse gas emissions to signatory nations.

Economic benefits of biodiesel. Economic benefits can be further divided into two: (1) reducing negatives and (2) inducing positives. The chief negative that could be reduced is the dependence on imported crude oil. The less the Indian economy is reliant on unstable, fluctuating, and politically volatile global oil markets, the better. The U.S. Department of Energy claims that the overall energy efficiency of biodiesel, as produced in the United States with soybeans as feedstock, is approximately 3.24 units of energy produced for every one unit spent in its production (U. S. Department of Energy 2006). This calculation is often the greatest point of contention for other forms of bioenergy in which the energy benefit margin is much more questionable. And the potential for less energy-intensive means of biodiesel production is much higher in India.

The main induced positive is the amount of capital that remains in the domestic economy. The money would likely encourage the development of local entrepreneurs and industry and could greatly benefit the agriculture-based economy, especially in rural areas. Farmers are generally interested in anything that can increase profits, such as a potential new market in biofuel feedstocks. The increased capital could mean added labor opportunities for the rural poor as well. Biodiesel could also be used for purposes other than transportation, such as for rural electrification, for cooking (instead of polluting biomass fuels like wood or manure), or for irrigation pumps. All of these uses could have positive impacts on rural, oil-producing communities.

The Government Scheme for Biodiesel Production

Recognizing the environmental and economic benefits of biodiesel as well as the difficulties of bringing together all the necessary components, the government of India has designed a plan for promoting the cultivation of inedible oil–producing plants for the production of biodiesel, focusing on a shrub called *Jatropha curcas.* Certain mutually dependent factors must all be in place for the commercialization of biodiesel technology, including, but not limited to:

1. reliable, efficient agricultural production of sufficient oilseeds;
2. infrastructure for seed collection, oil expression, and biodiesel conversion and distribution, among other things; and
3. economic incentives for all parties.

The plan. To help the production of biodiesel reach a reasonable scale,[3] the government has initiated a program to facilitate the activities of rural communities, entrepreneurs, and oil companies. This effort is intended to "demonstrate the viability of the program with all its linkages in different parts of the country and widely inform and educate the potential participants and stakeholders" (Government of India 2003, 119). The program has been designed to occur in two phases and is to be coordinated by the Council of Scientific and Industrial Research (CSIR)/Central Salt and Marine Chemicals Research Institute (CSMCRI), a major government research organization, and DaimlerChrysler, a multinational company (Francis et al. 2005).

Phase I began in 2003 and will last until 2007 with a budget of 1496.16 Rs. crore (approximately US$300 million). The initial goals were to establish nurseries, plant the trees, establish the initial seed expeller and transesterification centers, and finance research and development on improving the agronomic and production processes that currently limit profitability. The explicit goal of this stage was to "prime the pump" for private investment and establish markets using public funds, but this stage also included private investment on all levels, especially by oil companies at the processing phase in order to tap into existing distribution infrastructure. There were to be demonstration plantations covering a total of 400,000 hectares in eight regions. Each site was to have approximately 50,000–60,000 hectares of coverage, or the amount needed to produce the 80,000–100,000 tons of feedstock necessary for an economically scaled transesterification plant. Four selected sites in four different states were to be on designated forestlands and were to be implemented and managed by Joint Forest Management (JFM) Committees[4] and the Department of Social Forestry. The remaining four sites were to be on nonforest

[3] The Indian government has a stated goal of achieving a 20 percent biodiesel/80 percent fossil diesel mixing capacity by 2012 (Government of India 2003).

[4] JFM Committees are management organizations made up of both local stakeholder representatives and government foresters.

lands, including on marginal farmland, in farmers' fields as live fencing, and on public lands along roads, highways, canals, and railroad tracks.[5] This second set of sites has been selected for strategic reasons and will be implemented by nongovernmental organizations (NGOs), self-help and user groups, cooperatives, public and private partnership bodies, and perhaps other entities. In addition to the designated sites, funding will also be available to develop plantations on other lands, including *panchayat*[6] land and areas already involved in other development programs such as watershed development projects. This oil would be available first for use by the rural community, with surpluses being sold to processing units.

Phase II, beginning in 2007 and ending by 2012, assumes that farmers will have a positive experience during the initial phase and will be interested in continuing their involvement and in geographically scaling up to meet the intended goals. This phase is intended to be entirely self-funded while still maintaining the more successful efforts initiated during the initial period. Some government loans and subsidies may be necessary, as well as continued research and extension.

Why Jatropha curcas? Jatropha curcas is a small tree belonging to the Euphoribiaceae family. It is native to Central and South America, but it has been naturalized in India for many generations and is grown in many other countries throughout the tropical world. Many of its characteristics make it a logical choice for biodiesel.

- *J. curcas* is an incredibly robust plant. It grows in areas with as little as 300 millimeters of annual precipitation and has been seen to tolerate periods of drought by shedding its leaves to reduce transpiration (its leaves then add to the soil organic matter and improve soil health).
- It appears to flourish in even the worst soils, including acidic, alkaline, saline, sandy, gravelly, and nutrient-poor soils, although soil quality will certainly affect the yield of oil.
- As a wild plant it has few known problems with diseases or pests, including roaming livestock, which will not eat it, and therefore would require much less effort in the form of maintenance. As a result *J. curcas* is popular as a "live fence" for blocking livestock's access to certain areas.
- *J. curcas* is fairly easy to propagate—either by seed, vegetative cuttings, or, more recently, tissue culture—which lends it to easy dispersal.
- In nonintensive contexts it grows fairly quickly and begins to yield in the first year under ideal conditions, reaching maximum yield by the fifth year, and it has been reported to produce for 30 years or more.
- The oil produced is of the right quality and is of sufficient quantity (~30 percent oil by weight of seed) for biodiesel. The oil is inedible, and therefore its use as a fuel source, rather than for human consumption, seems reasonable in a country that has a serious edible oil deficit. Tests have shown that the oil is suitable for biodiesel production, and with a reasonable yield it could prove economically feasible to grow.
- The processed seed and byproducts create several marketable products. The seedcake (the dry material left over after the expelling of the oil) is an outstanding soil amendment, with a high mineral and nutrient content, and even has some advantageous pesticidal properties against soil nematodes and vector snails. If the process for removing the toxic content can be commercialized or if robust, nontoxic genetic strains are identified and distributed, the seedcake could also be used as high-protein animal feed. In biodiesel production, glycerin is created as a byproduct and can be sold for commercial industrial usage or soap production. *J. curcas* products have also been used in numerous countries for medicinal purposes, such as purgatives, which could prove to be another source of income from its production (Francis et al. 2005).

[5] Indian Railways, a publicly held company, is the most extensive rail system in the world, carrying more than 1 million tons of freight and 14 million passengers daily. It is the nation's single largest consumer of diesel fuel and the largest potential consumer of biodiesel (http://www.indianrail.gov.in/).

[6] *Panchayats* are a collective form of governance among rural villages in India. They usually consist of five villages including a central village (*Encyclopedia Britannica* 2007).

Policy Issues

Ecological Issues

The somewhat anecdotal information about *Jatropha curcas* from government promotional materials (Government of India 2005) may suggest that the species is a miraculous silver bullet. A closer investigation reveals several possible pitfalls.

A limited-purpose plant? Jatropha curcas presents a concern for food security because it is in some ways a limited-purpose tree. Although it provides some secondary benefits to the grower (shade, soil organic matter, erosion prevention, and fencing, as well as some of the other benefits already listed), at present it offers little or no direct economic benefit to the farmer except for oil production and the seedcake as fertilizer and pesticide. Some of the same traits that make the species attractive for biodiesel reduce its popularity with rural people with limited resources. For example, the currently available genotypes of *J. curcas* contain toxic phorbol esters and also some antinutrients such as lectins and trypsin inhibitors, which make the oil inedible and the leaves unusable for fodder (Becker and Francis 2005). If farmers do not have access to proper technology, inedible oil is of little use to them beyond use in small oil-burning lamps. The oil is also a potential danger because there are reasonable concerns about accidental consumption and the physical risk of handling the toxic seedcake. Technology to allow farmers to use the oil directly, such as for powering cooking stoves, grain mills, or irrigation pumps, is being developed but is not currently available and will likely be expensive for rural communities. Also, the wood is not dense and is therefore useless as fuelwood or lumber. These issues may affect farmers' willingness to plant *Jatropha curcas* as a primary source of income.

A wild plant? Although *Jatropha curcas* has grown in India for many generations, little is actually known about it on a scientific level. In many ways it is still a wild plant, and some in India consider it a weed (Raju 1998, 132). India has suffered from the introduction of numerous other weedy or invasive exotics, such as *Prosopis juliflora,* a tree introduced by development agencies for reforestation and fodder production that now dominates much of the landscape with its thorns and invasive weedy tendencies (Raju 1998, 5). Although there is little evidence that *Jatropha* could cause similar problems since it has become naturalized in many areas, such problems are not out of the realm of possibility. At the very least, *Jatropha curcas* could prove to be a biodiversity concern if planted in vast monocultures.

Much research is currently underway, but little is known about basic agronomic best practices, such as spacing, pruning, and maintenance, the potential yields of *J. curcas* on various qualities of soil and in various agroecological contexts, and the potential for pests and diseases as production is scaled up into large plantations. Much of the data on which the cost-benefit analyses are based are not from large, intensive plantation settings that could achieve economically sustainable yields.

Perhaps most important, to achieve higher and more reliable yields, researchers are using better land and more inputs in the form of fertilizer and irrigation water (Tamil Nadu Agricultural University, personal communication), but these inputs then detract from the overall ecological and energy efficiency of the crop. This practice also raises some concerns about the use of higher-quality arable soils for the production of energy crops, which in certain circumstances may displace food crop production. To achieve reasonable ecological and financial profit margins, farmers will also need high-quality genetic material to improve the quality of planting stock for particular growing conditions as well as to raise the percentage of oil content. Because most farmers would be propagating from seed and because *J. curcas* is an open-pollinated plant, there is potential for significant genetic diversity between individual plants, in which some plants produce high yields next to others that barely produce at all (Francis et al. 2005). Large-scale breeding and nurseries will be necessary to reduce the variance in oil production and to select out less-productive phenotypes. This type of breeding, along with the dissemination of plant material and information, takes many years and serious public investment.

Social Issues

In promoting this new technology, the India Vision 2020 planning document claims that an optimistic scenario in which 10 million hectares are planted with *Jatropha curcas* could lead to production of 7.5 million metric tons of fuel annually and year-round employment for 5 million people. Moreover, the advantage of biofuels "is that they can generate tens of millions of rural jobs and stimulate enormous growth for rural incomes, especially among the weaker section. Therefore, these strategies should not be regarded from the narrow perspective of energy alone, but from the wider perspective of national development" (Government of India 2002, 74). Perhaps the most important question for policy makers is, how will these programs really affect people in these regions? There are a number of legitimate concerns.

A pro-poor technology? Helping the poorest of the poor escape from poverty traps continually proves to be an elusive goal. For biodiesel production to be economically feasible, the price must remain lower than that of fossil diesel. The net price of biodiesel depends heavily on the production cost of the feedstock oil, which in turn depends on the cost of rural labor to plant, maintain, and harvest the trees. The seeds must then be processed to expel the oil, which is converted to biodiesel. For the sake of economies of scale, the government plan envisions processing plants that that can expel 7,500 metric tons of oil a year and produce 100,000 tons of biodiesel through transesterification a year. Assuming a conservative rate of recovery of oil from seed of 28 percent, it would take 3,571 kilograms (kg) of seed to produce one ton of oil. Assuming a cost of US$0.11/kg for seed and processing costs of approximately US$19.60/ton, the overall cost of production would be approximately US$407.80/ton, which translates to US$0.53/liter of biodiesel. The sale of the glycerin and seedcake byproducts could optimistically reduce the net cost to approximately US$0.40/liter. Even though this is considerably lower than the cost of production of biodiesel in Europe, for example, it is still higher than the untaxed base price of fossil diesel in India, which is approximately US$0.35/liter (Francis et al. 2005).

This cost analysis illustrates two effects: (1) the government would have to not only pay to promote the production of biodiesel, but also forgo taxes on biodiesel in order for it to remain competitive;[7] and (2) a large portion of the profits from biodiesel production will be captured at higher levels of the value addition chain. As such, most of the profits will not be accessible to wage laborers or smallholders involved in production. In fact, with fixed production costs dampened by low fossil diesel prices, the higher-value producers will insist upon low seed feedstock prices in order to maintain a profit margin. The ensuing necessities of economies of scale for the plantation of *Jatropha curcas*, as well as for the industrial processes of oil expelling and transesterification, will create incentives for larger holders. Recent evidence has shown that competing with fluctuating imported fossil diesel prices has already proven to be difficult for biodiesel sales in India, causing some producers to stop production in order to suspend losses due to uncompetitive costs of operation in the short term (Srinivas 2007). Although entrepreneurs may be able to cover their loses, limited-resource farmers cannot as easily forgo their income nor be expected to invest in risky plantations that will take multiple years to recover any capital expenditures.

If there is not a specific policy to promote smallholders and smaller, decentralized production facilities, these smaller producers may find their access to this sector limited. Even if all of the jobs that the government envisions were created, the majority of them would likely be low-paying, seasonal jobs that could hardly be expected to raise the standard of living in rural areas. Aside from harvest and seed-processing periods, most of the labor would occur in the first year of establishment and then diminish to fewer jobs in maintenance and weeding. Most of the profits for biodiesel production would be claimed by entrepreneurial businesses and individuals that can meet the large-scale needs of production as well as by higher-skilled staff working in centralized processing plants. It is more difficult to predict the effects on the smaller producers under whose name the programs are being promoted.

Whose land? Whose wealth? The quality and ownership of the lands intended for plantation must also be discussed. The effort to promote cultivation of *Jatropha curcas* is often described as having a dual purpose of creating energy plantations and addressing the degradation of low-productivity wastelands. India has 63.85 million hectares (20.7 percent of the entire country) that are referred to as "wastelands" (Government of India 2000). But what exactly determines a "wasteland" classification? Shiva (1991) points out that the idea of "wasteland" is a colonial construction and a revenue

[7] Biodiesel taxes would not be forgone if Indian Railways were the chief consumer, since it is owned by the Indian government.

classification, not necessarily an ecological classification. Areas that did not create revenue for the state did not interest the state bureaucracy and were therefore considered "wastelands." These lands were not considered a waste, however, for the local people, who relied on them for firewood, fodder, grazing land, and other foraged, non-intensive products. Shiva's argument points out that the state and private enterprise hold differing views of what is considered "productive" land. The government's classification of wastelands has several ambiguous categories (see Table 1). Government plans call for plantations on forest, nonforest, and "other" land (Government of India 2002, 120–121), and they set quantifiable limits, in terms of nitrogen and phosphorus, on the soil quality of land they will subsidize for biodiesel feedstock production. There are reasonable concerns, however, that if prices for biodiesel rise to a certain level, cultivation of nonfood crops such as *J. curcas* or other biodiesel feedstocks will extend to other arable lands or threaten some forms of biodiversity.

Beyond the question of land quality and productivity, issues of ownership and entitlement must also be addressed. Many of the lands described by the plan are held by the state and managed by collaborative groups of government and user group representatives, as with Joint Forest Management Committees, or are owned collectively by communities, such as *panchayats*. Many of the proposed nonforest areas are also on privately held land. Both types of ownership present obstacles not only for efficient production of oil feedstock, but also for egalitarian means of production whereby the livelihoods and food security of the disempowered are also considered.

In the past collective ownership situations have proven very difficult to manage for large-scale commercial production without less-empowered parties being overrun by industrial or government interests, even disregarding the inevitable issue of corruption. A "tragedy of the commons"–type situation is almost unavoidable when outside interests stand to gain financially from the exploitation of common lands (Shiva 1991).

A brief look at the history of such efforts reveals a very similar and prescient experience with the promotion of eucalyptus plantation by social forestry programs. Although the debate has cooled in the past few years, the subject of the ecological and social degradation brought on by massive government social forestry programs to bring "wastelands" into production through large-scale

Table 1: Wasteland Classifications and Areas

Category	Total wastelands (ha)	% of total area
Gullied and/or ravinous land	2,055,335	0.65
Land with or without scrub	19,401,429	6.13
Waterlogged and marshy land	1,656,845	0.52
Land affected by salinity/alkalinity—coastal/inland	2,047,738	0.65
Shifting cultivation area	3,514,220	1.11
Underutilized/degraded notified forest land	14,065,231	4.44
Degraded pastures/grazing land	2,597,891	0.82
Degraded land under plantation crop	582,809	0.18
Sands—inland/coastal	5,002,165	1.58
Mining/industrial wastelands	125,213	0.04
Barren rocky/stony waste/sheet rock area	6,458,477	2.04
Steep sloping area	765,629	0.24
Snow-covered and/or glacial area	5,578,849	1.76
Total wasteland area	63,851,831	20.17

Source: Government of India 2000.

monocultures of eucalyptus for industrial use is still a sensitive topic. For smallholder farmers on marginal lands, landless laborers, and certain *panchayat* groups that were victimized by colluding commercial and government interests, the species itself became demonized. The eucalyptus social forestry system, justified by familiar claims that it would reduce poverty, improve degraded lands, and meet the needs of a booming economy, left participating *panchayat* members and small farmers without sources of fuelwood and fodder. Furthermore, it displaced landless laborers from traditional labor as agricultural workers and sharecroppers on these lands so that absentee landowners could guarantee production for pulp and rayon factories. Meanwhile, the eucalyptus plantations further degraded the soil and lowered the water table because of inappropriate management schemes (Raintree 1996; Shiva 1991; Hiremath and Dandavatimath 1996).

Production on private lands lends itself to similar problems. India has maximum landholding laws for individuals to help reduce landlessness and to prevent hoarding by wealthy individuals or corporations. The scale of production of *Jatropha curcas* oil on disparate smaller holdings will certainly be lower than on larger-scale monocultures, which raises concerns about how these small holdings can meet the base demand for feedstock to continuously operate a scaled-up expelling and transesterfication facility. A different and more complex infrastructure and system of incentives will be necessary to encourage smaller holders to invest in *Jatropha curcas*, even at the level of border cropping or live fencing—approaches that would help maintain biodiversity and reduce the potential for displacement of food production.

Stakeholders

There are potentially four main stakeholder groups to consider: (1) government agencies that can promote the development of various biodiesel production programs; (2) private investors whose capital will be needed for production schemes and who also stand to gain considerably from the sale of biodiesel; (3) the consumers of the final biodiesel product; and (4) the producers of the oil feedstock. This final category may include either small or large holders of land and must also include the labor necessary to plant, maintain, and harvest seed crops, as well as the labor involved in processing and distributing the final product.

Policy Options

The current government plan, in which public-private partnerships will fuel the development of plantation schemes, production infrastructure, and distribution, is the best mix of market incentives and public direction for the development of poorer rural regions and the agricultural sector. At the same time, this public-private approach can proactively protect the environment and national security interests. The two-phase plan, as already described, has sufficient incentives to encourage broad investment by private entrepreneurs on all levels and will still protect and benefit the rural poor by infusing them with large amounts of financial capital, boosting employment and creating numerous small-scale investment opportunities. Investment by risk-averse marginal farmers in unproven technologies will need proper promotion through various means, such as subsidized loans, tax incentives, and effective extension strategies. This project leaves ample room, however, for profit motives and other market forces to take effect, and there will no doubt be a long-term demand for oil-producing plants around which to build a reliable market. The ecological and social concerns described will be worked out iteratively through research during the process, but the present demand for cleaner energy makes the program worthwhile.

The government should further consider some of the issues described and redesign its promotion strategies to ensure a more sustainable and just intervention. The livelihoods of the rural poor are vulnerable and contingent on a variety of institutional arrangements within public, private, and civil society sectors. Development interventions on their behalf must be durably and dynamically pro-poor in design and adaptable to the changing needs of the population. Programs and technologies that allow rural producers to be the primary beneficiaries of the oil are given minor roles in the government report on biodiesel (Government of India 2003), but they should be more actively promoted. Examples of such technologies that could be widely dispersed are smaller-scale collection, expelling, and transesterification technologies, direct-use oil cookstoves, milling machines, irrigation pumps, and even diesel generators for lighting and other uses. If the producers are the direct beneficiaries of the product, aversion to widespread adoption is more likely to disappear.

Programs like the AMUL dairy cooperatives, where many individual producers bring milk to a central collection point and collectively take advantage of value-adding high-tech equipment and therefore higher prices, have ushered in major changes for marginalized dairy producers as well as the general public (see Esman et al. 1997). Although the dairy and biodiesel programs are vastly different and deal with different constraints, the model in which many small producers take advantage of collective management to gain access to technologies required for economies of scale could be replicated for oilseeds. Integrated agroforestry techniques such as alley cropping, contour bund planting, live fences, and border plantations should be promoted over monoculture plantations. A more diverse regime of oilseed-bearing tree species such as *Pongamia pinnata* and jojoba, which may have more direct uses, like fodder production, nitrogen fixation, lumber, and fuelwood, should be more actively promoted over monoculture *J. curcas*. These diverse, stable systems could better meet the dynamic needs of rural producers and protect biodiversity.

All of these changes would require, however, greater public intervention in research and extension and in creating proper incentives for small producers (at the cost of lost efficiency, productivity, and profitability, and therefore the potential interest and capital investments of the private sector). If productivity declined and the end-user focus shifted away from wealthier urban fuel consumers toward lower-capital-producing, poorer rural people, commercial interest in promoting infrastructure could also decline. Possibilities for larger-scale environmental benefits from biodiesel use, like a reduction of greenhouse gases, may also be reduced if usage remains mostly in the rural areas. The increased complexity of diverse sources of production and end product usage could cause the project to lose focus, threatening all beneficial outcomes. The AMUL dairy cooperatives took nearly 20 years to gain significance in one small area before being mobilized as Operation Flood (Esman et al. 1997). Can the environment or the economy wait that long for greener energy?

The government should avoid involvement in promoting dubious new technologies that will cause uncertain socioeconomic impacts. In the early 1990s attempts by the government to promote *Jatropha curcas* for the purpose of oilseeds found little interest among poorer populations dependent on their land for their livelihoods and lost momentum in the private sector owing to a lack of production and profits. The market alone should direct the development of biodiesel technology. When global oil prices are sufficient to create a demand for alternatives, the supply will be met on the basis of profit motives.

Assignment

Your assignment is to recommend to the government a policy to guide the ongoing development of biodiesel in India that takes into account the interests of the various stakeholder groups.

Additional Reading

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